CENE 486C

50% Design Report

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Team Flaming Bunnies (2016-2017)

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1.0 ACKNOWLEDGEMENTS

We would like to acknowledge and thank Tom Runyon who is the coordinator hydrologist for the Coconino National Forest. Tom is our client but also a strong supporter for the work we are doing. In addition, we would like to thank Kit MacDonald who is the soil and watershed program manager for the Coconino and Kaibab National Forest. Kit has helped us with fieldwork and gathering samples. As well as providing feedback and support towards any of our concerns. Both professionals continue to support our design project and we are grateful for their contributions.

2.0 PROJECT DESCRIPTION

2.1 BACKGROUND

The Allan Lake Wetland Restoration project aims to restore the wetlands’ historical ability to retain water and support wetland vegetation. The fine particle clay layer that had acted as an impermeable water-holding layer was disturbed during a habitat improvement effort, resulting in a loss of wetland function. The purpose of this project is to improve the distribution and retention of water in the wetland area. The Forest Service has a rough idea of how they would like to approach the restoration, they have previously used a bull dozer and half a dozen workers to carry out a test restoration in a single section. Figures C1 through C3 in the Appendix show the differences that are observable at the site between the unrestored area and the test restoration section. The Forest Service then put out a bid to contractors to see how much it would cost to have the entire lake restored like their test section, however they did not include a soil analysis of the site, which made the bids range from $40,000 to $250,000. The main objective for the students is to conduct the soil analysis, and then based on the soil analysis complete a cost analysis for the restoration to find a more accurate and exact price for our client Tom Runyon.

Allen Lake is located 2.7 miles north of the intersection of Lake Mary Road and Stoneman Lake Road, along Lake Mary Road where it can be seen in Appendix A (Latitude 34º 49’ 34.09” N, Longitude: 111 º 26’ 27.45’’ W). Currently, the lake is a series of ditches surrounding a grassy field, as shown in the Appendix B. In 1986 Arizona Game and Fish tried to improve waterfowl habitat by creating the series of ditches in the seasonal Allan Lake area. Their thinking was that this would allow the water to pool, creating a permanent lake, and would protect the waterfowl from predators. By creating the ditches with bulldozers and explosives, they disturbed the water retention layer in the soil, causing the lake to dry much quicker and thus reducing waterfowl habitat.

Our client is the United States Forest Service (USFS). Tom Runyon is our secondary client who is a coordinator hydrologist for the Coconino National Forest. Our stakeholders are the species and plants of the wetland, people who own land and utilities adjacent to the impacted areas, Arizona Game and Fish, and the general public who has unrestricted access to the site.

2.2 SITE CONDITIONS

During the fall when the site was surveyed and the soil, samples were gathered. The site was relatively dry and easy to traverse. This can be seen in Figure C1 in the Appendix. This contrasts with the current conditions of the site. Currently the site is heavily flooded with some snow still on the ground, as shown in Figures C4 though C6 in the Appendix. This poses the problem of not being able to gather more soil samples until the area has dried some. Fortunately, the lake is currently at full capacity and overflowing through the natural spillway so flooding cannot worsen. Due to this, the main limitation of this project is what the site and weather conditions are like. This can limit the project by delaying the soil gathering as well as prevents the students from conducting additional survey work. The current conditions impose a delay in collecting more soil samples for the hydraulic conductivity tests and the proctor compaction tests.

2.3 TASKS AND SUB TASKS

Below is an outline of the tasks that need to be finished in order to successfully complete the project [5].

- Task 1.0: Research
- Task 2.0: Field Work
  - 2.1: Survey & Create a Topographic Map
  - 2.2: Soil Sampling
  - 2.3: Soil Profile from Auger Boreholes
- Task 3.0: Geotechnical Lab Analysis
  - 3.1: ASTM D2974-Moisture Content
  - 3.2: ASTM D2974-Organic Content
  - 3.3 ASTM D4318-Atterberg Limits
  - 3.4 ASTM C325-Wet Sieve Analysis
  - 3.5: ASTM D5084-Hydraulic Conductivity
  - 3.6: ASTM D-698-Proctor Compaction
- Task 4.0: Develop Design
  - 4.1: Develop Compaction Specification
  - 4.2: Cut and Fill
  - 4.3: Cost Analysis
- Task 5.0: Project Management
  - 5.1: Communication
    - 5.1a: Client Meetings
    - 5.2b: Team Meetings
  - 5.2: Deliverables
    - 5.2a: Final Report
    - 5.3b: Presentation
    - 5.3: Website

3.0 Technical Section

3.1 Testing and Analysis

Prior to conducting soil analysis, soil sampling and surveying work were both completed as part of the fieldwork for the project. While collecting samples at the project site, we used a bore auger instrument to collect a soil profile. One of the bore logs used during the acquisition of samples can be seen in Appendix E. A total of 28 soil samples were initially collected from 13 sampling sites by the team, and shown below are some of the representative profiles:

Figure 3.11: Soil profile of the undisturbed sections of Allan Lake.

Figure 3.12: Soil profile of the side cast mix near the trenches.

Figure 3.13: Soil Profile of the Trenches.

Based on the soil samples collected, we found that parts of the wetland was undisturbed by Arizona Game and Fish. Thus, these soil profiles represent the soil layers for the undisturbed area (before the excavation of Arizona Game and Fish) and the disturbed soils, which are the side casted mixed piles and the trenches. The first layer of soil from the undisturbed area (shown below in Figure 3.14) is the hydric layer, which indicates heavy organic deposits, periodical moisture, and heavy clay. The second layer is the oxidation layer and iron deposits, but also heavy clay. The third layer is the sandy clay loam mixture. On the next page, a simplistic image of the layers is shown:

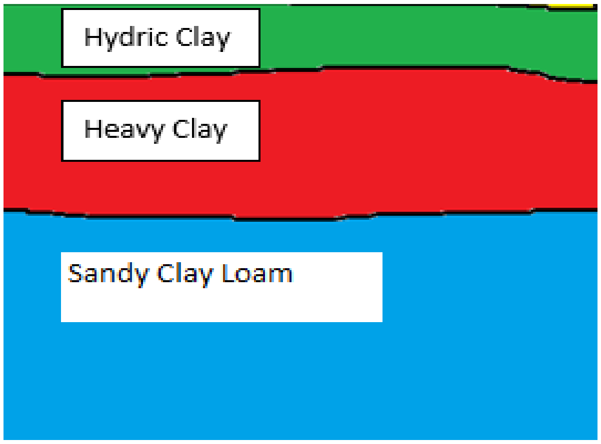


Figure 3.14: The soil profile of the undisturbed soils at Allan Lake.

The following figure gives a visual representation of the soil profile of the side cast mixture near the trenches:

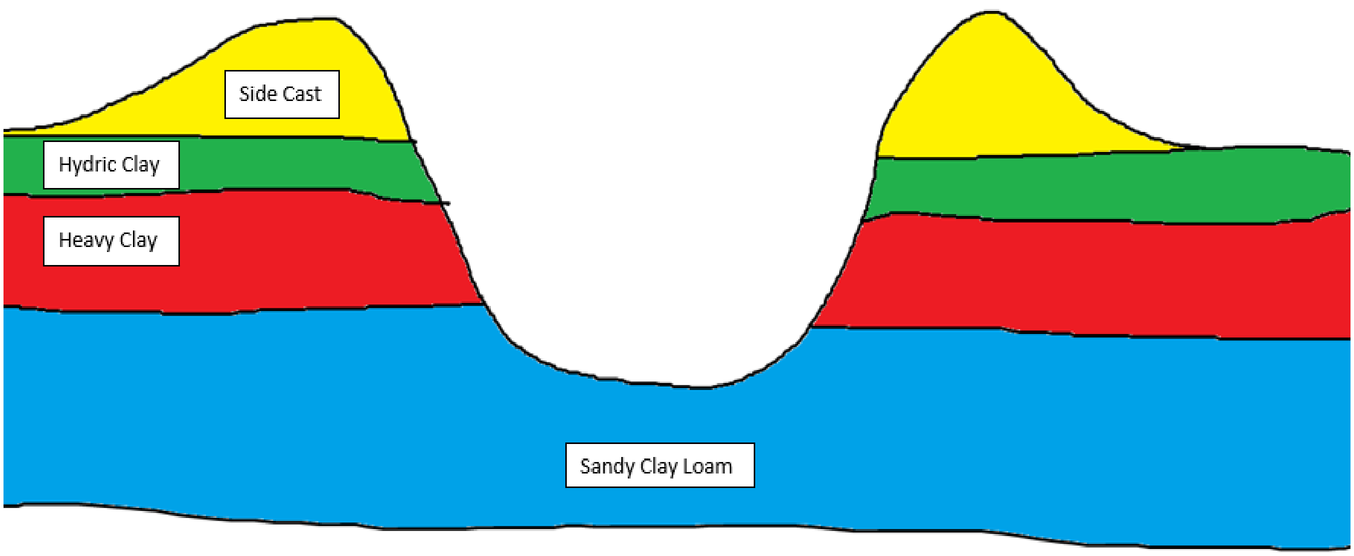


Figure 3.15: The soil profile of the side casted mixture near the trenches.

After collecting soil samples and capturing each soil profile, we conducted surveying work. The students conducted multiple site visits in order to collect data points. On our first day of surveying, we established 5 control points with a total station. However, due to the size of the area a GPS survey unit was borrowed from the forest service and used to complete the majority of the survey after the first day. Kit MacDonald assisted with the setup and calibration of the GPS survey unit during the 3 days it was used. Shown on the next page is the total station used for set the control points for the surveying work:

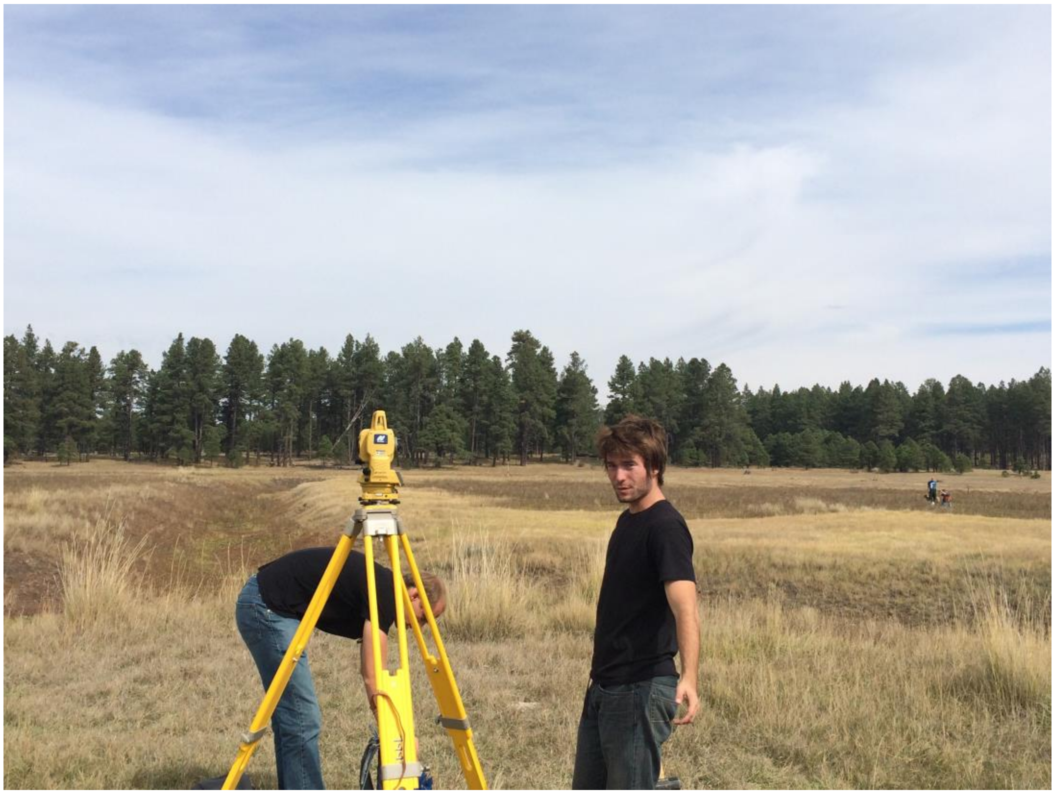


Figure 3.16: Surveying Allan Lake in the Fall of 2016.

Starting from October of 2016 and ending in December of 2016, we were able to collect 2871 points. With the help of the Forest Service and their GPS instrument, we were able to gather points for an area of 17 acres. Since the GPS instrument allowed for quick point taking, the following plan was developed: when measuring the trenches, a total of 9 points were to be taken in a line that runs perpendicular to the trench. Starting at the top edge of the trench, the next point was taken at ¼ of the way down, the next point was taken ¾ of the down the trench, and the final point on the one side of the trench was the tow, or the bottom of the trench wall. The process was repeated on the opposite side, in addition to taking a point at the thalwag. For the leveled sections of Allan Lake, a point was taken every 6 paces.

A topographical map was developed from the obtained points can be seen in the figure below. Breaklines are visible in this image that were inserted to help AutoCad construct an accurate topographic map.

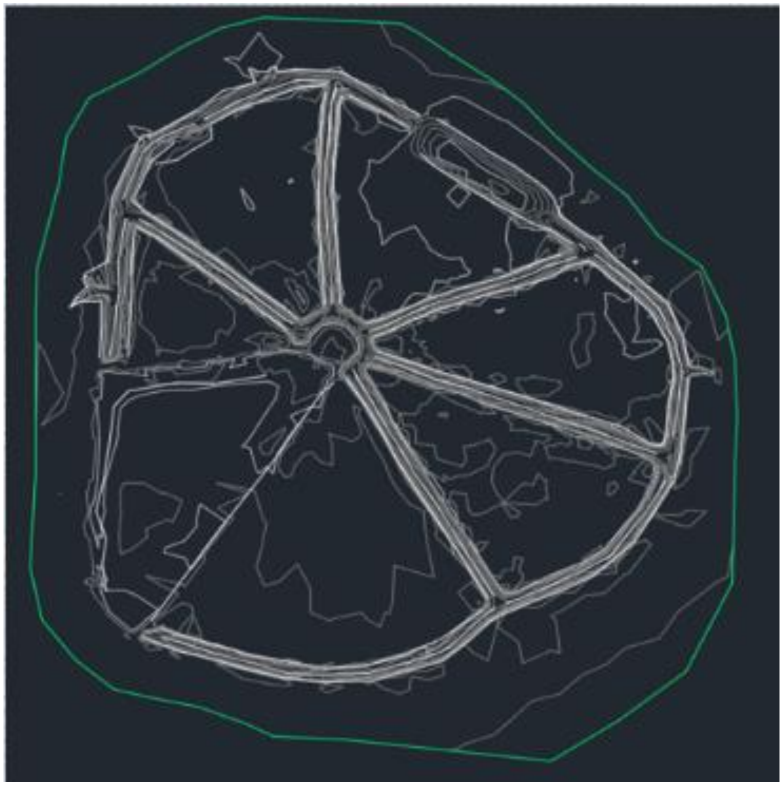


Figure 3.17: The topographic map of Allan Lake.

Also below is a developed TIN surface of Allan Lake:

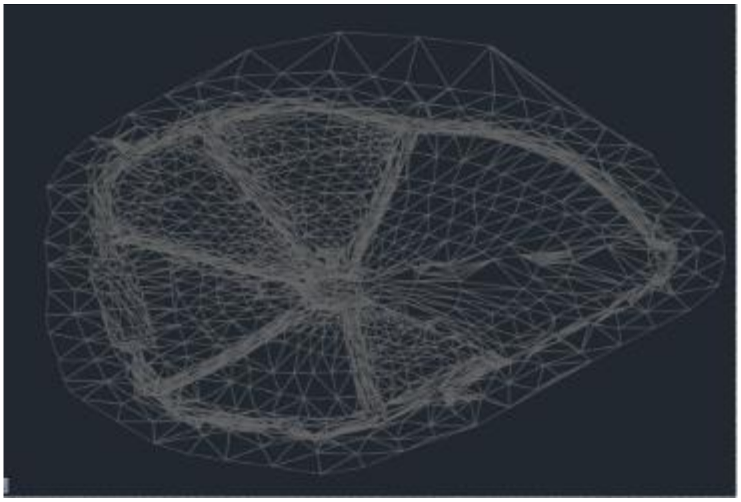


Figure 3.18: TIN surface of Allan Lake.

After conducting gathering samples and surveying, the team started on the geotechnical lab analysis. Our first geotechnical lab work was determining the organic content in the top soil (within 12 inches from the surface). Below is a table that shows the organic content of each soil profile as well as the average organic content and the standard deviation:

Table 3.19: Organic Results for the top soil in each sample soil profile.

Samples	Sample 1 (Undisturbed)	Sample 3 (Trench)	Sample 5 (Side Casted)	Sample 6 (Undisturbed)	Sample 9 (Side Casted)	Sample 11 (Trench)	Sample 13 (Undisturbed)
Organic (%)	8.17	6.92	9.12	8.74	8.13	7.65	9.56
Samples	Sample 16 (Trench)	Sample 18 (Side Casted)	Sample 21 (Undisturbed)	Sample 23 (Trench)	Sample 25 (Undisturbed)	Sample 27 (Side Casted)	
Organic (%)	6.63	7.79	11.73	7.24	9.41	9.05	
	Average = 8.47%		Standard Deviation = 1.36%				

Reference Appendix D to see the organic results for each of the samples per soil profile. It was noted that the average organic content in the top soil (within 12 inches of the surface) was 8.47% weight with a standard deviation of 1.36%.

3.2 Work in Progress

Currently, the soil tests that are being conducted are the Atterberg limits and Wet Sieve Analysis that should be completed within a few days. There was a delay in starting these tests due to a combination of the weather and our client being out of town. We wanted to verify that our strategy and methods would yield the results that is desired by our client. This was to prevent wasting any soil samples, as the site is still inaccessible for additional soil gathering.

3.3 Future Work Needed to be Completed

The work that is left for the team to complete is the proctor compaction tests and the hydraulic conductivity soil tests. These tests have not been started yet due to large amount of soil required relative to the amount that the students have. Once these tests have been completed, it can be decided roughly how much the site needs to be compacted in order to achieve the desired hydraulic conductivity. With this data the cut and fill estimate will be completed using the topo map. Using the cut and fill analysis in AutoCAD, we will then conduct a cost analysis of the different restoration methods possible to indicate which route will be the best option.

4.0 References

[1] T. Runyon. (2016, September 6). *Allan Lake Statement of Work* [Online]. Available email: tarunyon@fs.fed.us Message: Introduction.

[2] US Forest Service United States of Department of Agriculture (2016). *Allan Lake Wet Rest Decision Memo Final*. [Online]. Available Telnet: http://www.fs.usda.gov/ Directory: Allan Lake Wetland Restoration Project: Decisions

[3] US Forest Service United States of Department of Agriculture (2016). *Decision Cover Letter*. [Online]. Available Telnet: http://www.fs.usda.gov/ Directory: Allan Lake Wetland Restoration Project: Decisions

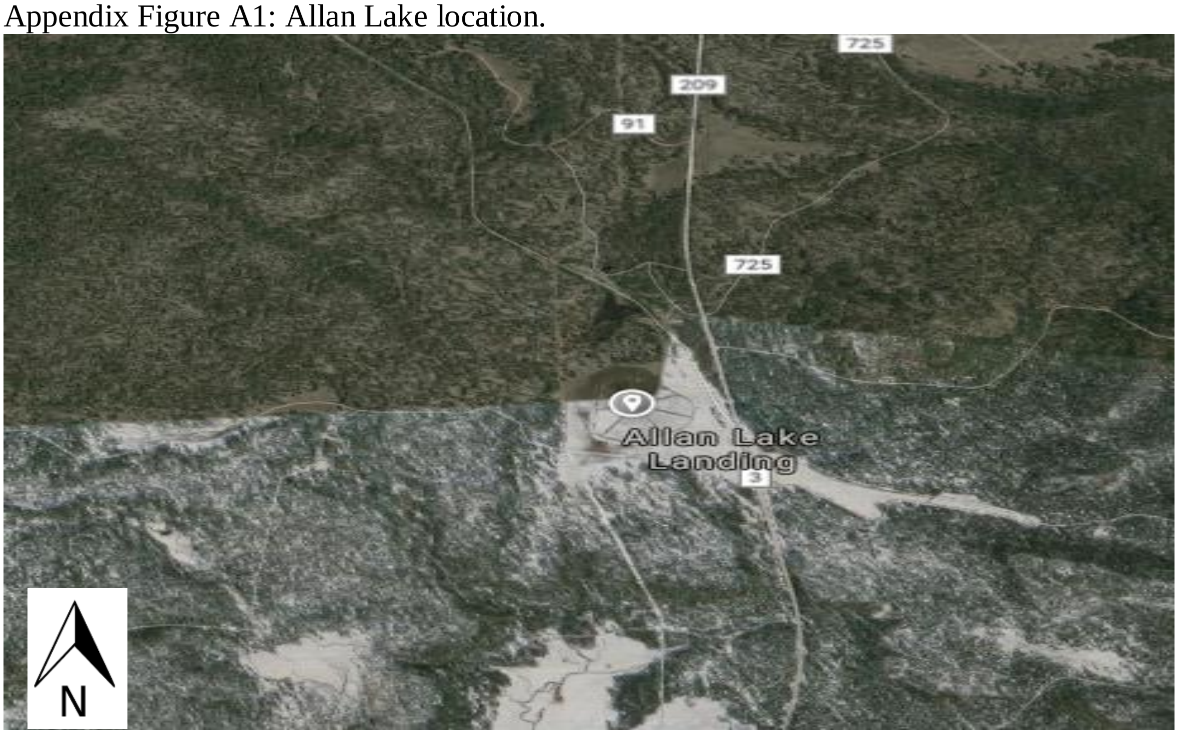
[4] Google Earth. (2016). *Allan Lake Google Earth* [Online] Available: FTP: https://www.google.com/earth/

[5] B. Gutierrez, G., Green, S., Clemons. (2016, December 2016). *Student Project Proposal.* Print.

5.0 APPENDICES

APPENDIX A- Location of Allan Lake on Google Earth [4]

Appendix Figure A1: Allan Lake location.



Appendix Figure A2: Allan Lake location.

APPENDIX B- Arial View of the Trenches of Allan Lake

Appendix Figure B1: View of trenches of Allan Lake.

APPENDIX C- Current landscape of the project

Appendix Figure C1: Differences in vegetation between the test restoration section on the right and the unrestored section on the left. (September 13th, 2016)

Appendix Figure C2: Small puddle of water in the deepest portion of the restored section. (September 13th, 2016)

Appendix Figure C3: Unrestored trench in the southeast portion of the site. (September 13th, 2016)

Appendix Figure C4: Overview of flooded wetland (February 17th, 2017)

Appendix Figure C5: Looking at the test restoration section on the left and the unrestored section on the right, with the lake at full capacity. (February 17th, 2017)

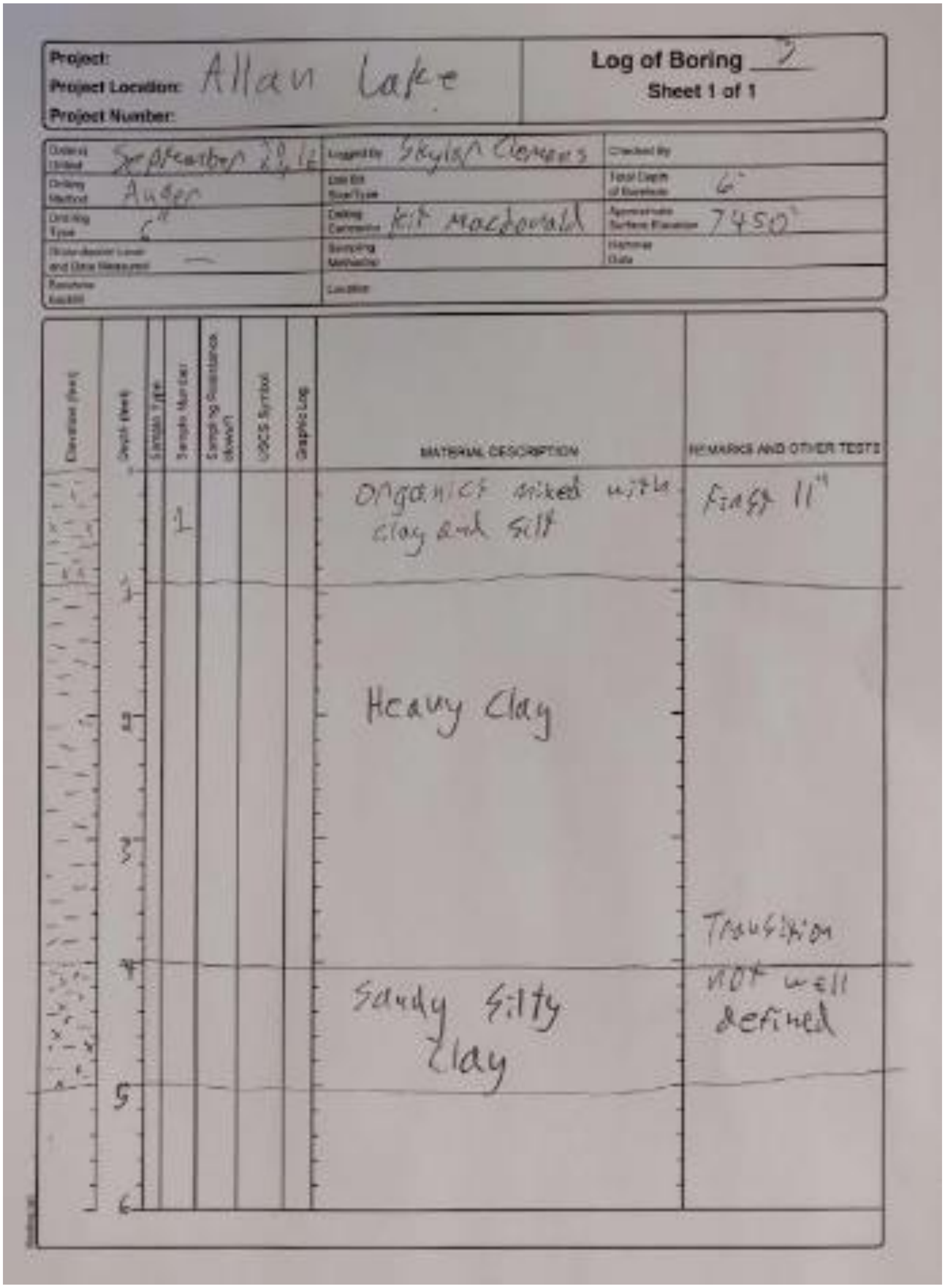
Appendix Figure C6: Trenches in the unrestored area covered by ice during the winter. (February 17th, 2017)

APPENDIX D: Lab Results

		Before oven	After oven	After furnace		
Samples	**Wc**	**W1**	**W2**	**W3**	**Moisture (%)**	**Organic Content (%)**
1	21.83	52.14	47.52	45.58	17.98365123	8.168421
2	13.72	35.26	30.09	28.71	31.58216249	9.206137
3	14.15	44.3	41.95	40.15	8.45323741	6.923077
4	13.5	47.94	45.86	44.63	6.427688504	3.951173
5	13.82	34.13	31.89	30.38	12.39623686	9.118357
6	14.22	47.31	42.7	40.41	16.18679775	8.743795
7	21.83	40.97	38.84	37.55	12.52204586	8.206107
8	14.2	27.6	26.04	25.12	13.17567568	8.424908
9	13.97	40.48	35.51	33.89	23.0733519	8.13253
10	22.6	71.11	67.39	64.5	8.305425318	6.897375
11	22.27	90.47	84.3	79.89	9.946799936	7.653593
12	13.74	53.37	41.76	39.72	41.43468951	7.852194
13	14.4	31.97	29.41	28.1	17.05529647	9.562044
14	13.58	34.08	29.02	27.54	32.77202073	10.60172
15	14.05	35.28	31.91	29.99	18.86898096	12.04517
16	11.98	29.76	28.22	27.21	9.482758621	6.631648
17	14.57	29.55	28.23	27.23	9.663250366	7.898894
18	14.33	26.79	25.68	24.86	9.779735683	7.787274
19	13.23	36.17	32.52	31.1	18.9217211	7.946279
20	14.08	24.93	23.13	22.4	19.88950276	8.774038
21	22.27	39.19	37.61	36	10.29986962	11.72615
22	11.76	49.11	45.54	43.23	10.56838366	7.340324
23	13.84	45.18	41.69	39.81	12.53141831	7.239122
24	13.64	36.22	33.17	31.5	15.61699949	9.350504
25	11.36	32.31	29.61	28.04	14.79452055	9.41247
26	22.18	27.49	27.04	26.69	9.259259259	7.760532
27	22.7	38.07	35.83	34.74	17.06016756	9.053156
28	12.34	38.7	35.35	33.46	14.55888744	8.948864

Appendix Table D1: Results of the organic test.

Appendix E: Bore logs


Project:
Project Location: Allan Lake
Project Number:

Log of Boring 3
Sheet 1 of 1

Date(s) Drilled: September 28, 16
Logged By: Skyler Clemens
Checked By:
Drilling Method: Auger
Drill Bit Size/Type:
Total Depth of Borehole: 6'
Drill Rig Type: 6"
Drilling Contractor: Kit Macdonald
Approximate Surface Elevation: 7450'
Groundwater Level and Date Measured: —
Sampling Method(s):
Hammer Data:
Borehole Backfill:
Location:

Elevation (feet)	Depth (feet)	Sample Type	Sample Number	Sampling Resistance (blows/ft)	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	REMARKS AND OTHER TESTS
	0–1		1				organics mixed with clay and silt	Grass 11"
	1–4						Heavy Clay	Transition
	4–5						Sandy Silty Clay	not well defined
	5–6							

Appendix Figure E1: Bore log from sample site 3 in the undisturbed area